

## CLEAN VERSION OF AMENDED APPLICATION

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## OPTICAL COUPLING DEVICE

Priority Applications

**[0001]** This Application claims the benefit of priority under 35 U.S.C. §119 of German Patent Application No. 19934183.4, filed July 21, 1999, and is a national stage filing under 35 U.S.C. §371 of PCT Application No. PCT/DE00/02395, filed July 21, 2000.

Field of the Invention

**[0002]** The invention relates to an optical coupling device for injecting light between two optical-waveguide end faces, it being possible to vary the geometrical position of the one optical-waveguide end face, for example, an optical fiber, with respect to the other optical-waveguide end face, for example a fiber-optic chip, with the aid of a variable-length element which, via a holding device, carries the one of the two optical waveguides, and is fastened to the other optical waveguide through two holding blocks.

Background of the Invention

**[0003]** An optical coupling device is known, for example, from WO 98/13718. Such coupling devices are used in optical filters according to the phased-array principle with an injection face, which light enters at a specific geometrical position, the geometrical position influencing the output wavelength of the optical filter. Optical filters according to the phased-array principle are used, in particular, as multiplexers or demultiplexers in optical wavelength-multiplex operation (WDM), since they have a low input attenuation and high crosstalk suppression. The optical filter has, as its essential component, a plurality of curved optical waveguides of different length, which form a phase-shifter region.

**[0004]** German Patent Application DE 44 22 651.9 describes that the central wavelength of a phased-array filter can be established through the position of an injection optical waveguide, which guides the light into the optical waveguide. In this way, the central wavelength of the optical filter can be adjusted accurately through the geometrical positioning of the injection optical waveguide or the injection fiber. Since it is therefore desirable for the optical waveguides to be shifted relative to one another, the optical waveguides cannot be adhesively bonded directly to one another.

### Summary of the Invention

**[0005]** In the optical coupling device described in the Field of the Invention, the holding blocks are fastened to the chip, and the optical fiber is held on the variable-length element. In this case, the variable-length element may oscillate or bend, which causes temporary or permanent deadadjustment of the fiber, even though a certain degree of guiding is provided.

**[0006]** It is therefore an object of the invention to ensure improved guiding of the variable-length element parallel to its extension direction and to avoid deadadjustment during operation.

### Brief Description of the Drawing

**[0007]** FIG. 1 illustrates a side view of an exemplary embodiment of the Invention

### Detailed Description of the Invention

**[0008]** The optical coupling device mentioned in the introduction is embodied in that the variable-length element, or the holding element, is held by a spring element, which is spongily or porously designed and which is supported directly or indirectly on at least one of the holding blocks and allows movements of the variable-length element, or the holding element, in the length direction of the variable-length element, in which the variable-length element is extended or shortened, and prevents movement of the variable-length element perpendicular to the length direction of the variable-length element. The variable-length element, which is necessarily fastened further away to the other optical waveguide, that is to say the planar waveguide, presses against the holding element for the fiber, in order to permit the relative movement of the fiber with respect to the planar waveguide. The spring element is configured in such a way that residual movement perpendicular to the plane is maximally suppressed. The effect achieved by this is that the movement of the fiber relative to the chip takes place very exactly parallel to the chip face and virtually no deadadjustment perpendicular thereto occurs.

**[0009]** Since the spring element is spongily or porously designed and the wall thickness of the spring element is hence reduced in comparison with the wall thickness of the solid material, the desired elasticity or spring characteristic is imparted to the spring element. Through selection of the ratio between the remaining wall thickness and the hole size, it is advantageously possible to vary the elasticity in wide ranges.

**[0010]** In the invention, it is furthermore advantageous that the holding block can be adhesively bonded to the second optical waveguide (optical-waveguide chip, also known in the art as a planar waveguide) very close to the fiber, so that large levers are avoided. Undesired movements in the directions perpendicular to the desired extension of the variable-

length element are thereby reduced significantly.

**[0011]** An advantageous configuration of the coupling device according to the invention is that the variable-length element, the holding element and the spring element are arranged between the two holding blocks, and in that the holding element is designed integrally with the variable-length element and the spring element is designed separately therefrom. In this case, it is advantageous that the material of the spring element can be selected without having to take into account the requirements placed on the material of the variable-length element.

**[0012]** Another advantageous configuration of the coupling device according to the invention is that the variable-length element, the holding element and the spring element are arranged between the two holding blocks, and in that the holding element, the variable-length element and the spring element are designed integrally. This configuration has production-technology advantages and also has advantages relating to the operational reliability and the life of the arrangement.

**[0013]** Another advantageous configuration of the coupling device according to the invention is that the variable-length element, the holding element and the spring element are arranged between the two holding blocks, and in that the holding element and the spring element are designed integrally and the variable-length element is designed separately therefrom. Here again, it is possible to produce the holding elements and the spring element without having to pay attention to the material of the variable-length element.

**[0014]** Another advantageous configuration of the coupling device according to the invention is that the variable-length element, the holding element and the spring element are arranged between the two holding blocks, and in that the holding element, the spring element and the holding block connected thereto are designed integrally and the variable-length element is designed separately therefrom.

**[0015]** Another advantageous configuration of the coupling device according to the invention is that the spring element is formed by slots in the variable-length element, or the holding element, which lie in a plane parallel to the end faces and perpendicular to the length direction of the variable-length element. These slots can be employed particularly advantageously whenever the variable-length element, the holding element and the spring element, or alternatively at least the holding element and the spring element, are designed integrally with one another. The direction of the slots is also advantageous since, if the slots are rotated through 90°, for example, stability in the critical direction perpendicular to the chip plane is no longer sufficiently guaranteed.

**[0016]** Another advantageous configuration of the coupling device according to the invention is that an even number of slots is provided. Tilting tendencies can thereby be minimized.

**[0017]** Another advantageous configuration of the coupling device according to the invention is that the spring element is formed by bores in the variable-length element, or the holding element, which lie in a plane parallel to the end faces and perpendicular to the length direction of the variable-length element. Such bores are easy to machine-produce, it being possible to set the spring constant of the spring element through the size of the bores.

**[0018]** Another advantageous configuration of the coupling device according to the invention is that the length of the variable-length element is selected in such a way that the spring element is under prestress in the starting position of the variable-length element. This guarantees that, if it is designed separately from the variable-length element, the holding element follows the variable-length element when the latter contracts.

**[0019]** Another advantageous configuration of the coupling device according to the invention is that the two holding blocks are connected to one another by a link, the arrangement consisting of the two holding blocks, the variable-length element, the holding element and the spring element being provided with greater stability.

**[0020]** Another advantageous configuration of the coupling device according to the invention is that the two holding blocks are connected to one another by a frame, a respective link being provided at the top and at the bottom between the two holding blocks, and the links being produced in one piece with the holding blocks, so that they can be adhesively bonded with the latter to the chip.

**[0021]** Lastly, another advantageous configuration of the coupling device according to the invention is that the holding element has a ferrule in which the optical waveguide, or the optical fiber, is fastened. It would admittedly also be possible to fasten the fiber to the resilient element without a ferrule, for example by adhesive bonding in a V-groove. Nevertheless, it is preferable to use a ferrule owing to the accuracy of the fit and the avoidance of aging phenomena in the adhesive for adhesively bonding the fiber in the V-groove.

**[0022]** An exemplary embodiment of the invention will be described with the aid of the appended drawing, FIG. 1, which shows a side view of the exemplary embodiment of the coupling device according to the invention.

**[0023]** FIG.1 shows a side view of a coupling device according to an exemplary embodiment of the invention, in which two holding blocks 4, 6 (the first and second holding blocks, respectively) are fastened, for example adhesively bonded, on an optical-waveguide chip 2. The first holding block 4 carries a variable-length element 8. An optical fibre 10 is fastened to a holding element 12. The variable-length element 8 is clamped or adhesively bonded between the one holding block 4 and a holding element 12 for the fiber 10.

**[0024]** The variable-length element 8, or the holding element 12, is supported on the holding block 6 via a spring element 14. The spring element is formed by outer slots 16 and inner slots 18. The slots 16, 18 can also be replaced by bores. In the vicinity of the spring element 14, the material may also be spongily or porously designed.

**[0025]** For the spring element 14, it is only necessary for the wall thickness of the spring element to be reduced in comparison with the wall thickness of the solid material, in order to impart the desired elasticity or spring characteristic to the spring element 14. Through selection of the ratio between the remaining wall thickness and the hole size, it is possible to vary the elasticity in wide ranges.

**[0026]** In the exemplary embodiment that is shown, the two holding blocks 4, 6 are connected to one another via a link 20, which lies in the plane of the fiber-optic chip 2. The two holding blocks 4, 6 can also be connected to one another via a frame, which stands perpendicular to the face of the fiber-optic chip 2, which ensures that the coupling device overall is stabilized. In this exemplary embodiment, the links can be produced in one piece or adhesively bonded to one another.